

Behavioral Ecology of Narwhals in a Changing Arctic

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LONG-TERM GOALS

Our primary goals are to understand baseline narwhal (*Monodon monoceros*) behavioral ecology in the pack ice of Baffin Bay. We will collect data on the species' acoustic, movement, and diving ecology in the offshore pack ice of Baffin Bay over a 4 year long research program with three ecological focus areas (acoustic ecology, sea ice ecology, and foraging ecology). Our longitudinal and cross-population analyses will use a suite of ecological modeling approaches over a >2 decade period that encompass a period of sea ice decline and increased anthropogenic activities in West Greenland (1993-present).

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OBJECTIVES

Our objectives are to answer the following science questions:

1. Acoustic ecology: What are baseline characteristics of the acoustic repertoire of narwhals in the offshore Baffin Bay pack ice (depth-specific high frequency calls, echolocation clicks, and buzzes during foraging dives)? What is the ecophysiological and communicative function of various click types of narwhals in this high-latitude offshore ice covered habitat? How might acoustic communication and foraging ecology be impacted by increasing anthropogenic activities in Baffin Bay (increasing shipping, future transit through the NW Passage, seismic exploration, increasing tourism)?
2. Sea ice habitat selection: How are narwhals' movements in Baffin Bay related to sea ice concentration, distance to the sea ice edge, location of glacial outlets, and the timing of sea ice break-up (as measured by the date when sea ice concentration drops below some threshold)? How have these relationships changed over the past two decades of sea ice loss? Are there population-level differences in sea ice habitat selection?
3. Foraging ecology: Do the winter home ranges of narwhals overlap with high densities of Greenland halibut and are there habitat parameters that quantitatively describe the overlap of this predator and its prey? What is the potential predation impact on the offshore Greenland halibut stock as measured by bioenergetic models using updated narwhal abundance estimates, recent fisheries survey data, and knowledge of populations hot spots?
4. Predation: What are the spatial and temporal trends in the occurrence of killer whales in West Greenland? Given the loss of annual sea ice and purported increase in killer whales in the Canadian Arctic, do killer whale catch and observation data from West Greenland follow this trend and have narwhals been exposed to increasing risk of predation?

APPROACH

Pack ice field work

We designed and built an acoustic recording station set up at leads in pack ice within high-density offshore narwhal wintering grounds. This station records depth-specific high frequency calls, echolocation clicks, and buzzes on narwhal foraging dives. We take two approaches to collecting acoustic data from narwhals. First, we are deploying a 15Hz-480kHz Reson hydrophone with pre-amplifier and recording using a National Instruments sound card with a sample rate of 500 kHz. Recent studies using wide-band acoustic sampling in the Northeast Atlantic have documented killer whales (*Orcinus orca*), the largest delphinid, produce whistles with the highest fundamental frequencies ever reported (Samarra et al. In Press). These ultrasonic whistles may also occur in medium sized odontocetes (i.e. narwhals) but has never been studied. The use of this first approach will ensure that the sampling scheme used to collect baseline data on narwhal acoustics in the pack ice is not inherently constrained by *a priori* sampling decisions (where insufficient sampling frequency results in portions of whistles being missed). Second, we are also utilizing an Acousonde 3B as a stand-alone recording system that can be lowered to a large range of depths.

Field work in the pack ice is in spring 2012 and 2013. All personnel and equipment will be deployed and retrieved from the ice using an Air Greenland helicopter (AS350). The helicopter will be used for spotting groups of narwhals and identifying ideal locations for deploying hydrophones. We will also attempt to instrument narwhals with satellite-linked time-depth recorders (SPLASH tags, Wildlife Computers) from leads in the ice. SPLASH tags collect information on animal location via the Argos system in addition to information on diving behavior.

Analysis and habitat modeling

We are using an extensive data analysis of over 18 years of satellite tracking and dive data (1993-2009) from five different narwhal subpopulations (Dietz and Heide-Jørgensen 1995, Dietz et al. 2001, Heide-Jørgensen et al. 2002, Heide-Jørgensen et al. 2003, Dietz et al. 2008). The satellite tracking database includes tracking data from n=79 individual narwhals tagged in Melville Bay (West Greenland), Somerset Island (Canada), Eclipse Sound (Canada), and Admiralty Inlet (Canada), and Uummannaq (West Greenland). We will use the narwhal satellite tracking data to identify individual trajectories, focal areas, and population-level home ranges. We will examine speed, dispersal, and movements under different ice regimes and quantify fine scale winter habitat selection/sea ice characteristics within focal areas by extracting a suite of habitat variables and remotely-sensed data on sea ice conditions. Sea ice concentration data will be used to construct resource selection functions (RSFs), to compute long-term trends in sea ice parameters in specific regions of Baffin Bay identified as important to narwhals, and to compute sea ice parameters along the trajectories followed by narwhals. Satellite passive microwave data from SMMR and SSM/I (1979-present) (25-km pixel size) will be the primary data source for investigating ice trends. AMSR-E data will be used to compute specific parameters in the post-2002 period at a higher resolution (6.25 km pixel size). We will also use AMSR-derived daily sea ice velocity fields in Baffin Bay (supplied by Dr. Ron Kwok at the Jet Propulsion Laboratory) and SSM/I-derived sea ice velocity fields (from NSIDC in Boulder) to characterize the sea ice velocity and its variability. Finally, we will use information on the ice front location, discharge rates and advancement or recession trends in glacial ice drainage sites along the coast of West Greenland (Moon and Joughin 2008) where narwhals migrate to quantify preference or avoidance of glacial ice habitat.

We will compile all available data on killer whale occurrence, dedicated and opportunistic sightings, and harvest records in West Greenland and Baffin Bay since 1970s and look at trends in the occurrence of narwhal predators, as well as spatial and temporal overlap based on the spatial models of area use. These records are kept by the Hunting Department of the Government of Greenland and for each catch record of killer whales details are recorded by hunters (submitted in catch reporting annually) and are available to our study through our collaboration with the Greenland Institute of Natural Resources.

WORK COMPLETED

2012 Field work. We conducted our pilot field season in March 2012. Average air temperatures were -20C and sea ice was >98% concentration. We were based out of Niaqornat Greenland and flew a total of 10 days between March 21 and April 4. We had an additional 6 days of bad weather or helicopter problems requiring a technician. We flew a total of 22 hours and 47 minutes (average of 2.2 hours per day) and tested the two acoustic recording systems previously described: Reson hydrophone/National Instruments system (with both marine battery and portable 12V battery – lead acid sealed) and the Acousonde 3B. We recorded at 12 different stations between 50 and 250 m depths, and made 10 recordings with the Reson hydrophone (mean recording duration 1h 47 min, range 15 min – 5 h) and

10 recordings with the Acousonde 3B (mean recording duration 15:32 min, range 12:36 to 18:00) with narwhals present in the vicinity at distance of 200 m to 1 km. In September 2012, we set out fuel depots along the coast of West Greenland (Niaqornat, Qaarsut, Upernivik) for the upcoming March 2013 field work.

Analysis work. We have published two papers on narwhal ecology in 2012. One paper discusses recent sea ice entraps in narwhal summering areas together with fall ice freeze-up trends, and the second paper is on cranial morphology across sub-populations. We are working on a manuscript relating winter movements in Baffin Bay to fluctuations in sea ice cover, and expect to have that completed by next year.y

RESULTS

Our primary accomplishment for the first year of the project was a successful pilot study in the pack ice of Baffin Bay in 2012. Preliminary findings demonstrate that narwhals make very high frequency clicks, up to 200 kHz. These frequencies not been recorded before from narwhals. We also recorded foraging buzzes concurrent with behavioral observations of foraging diving and are in the process of examining collected data. The pilot study demonstrated that it is necessary to be close to pods of narwhals (<1 km) to make high quality recordings. This is complicated considering the moving sea ice landscape, skittish whale behavior, restricted landing sites on the ice with a 2,200 kg helicopter, and unstable small weather systems (e.g. fog and snow) moving in and out. However we were able to get good access to pods of narwhals several times during our work. The Reson hydrophone and National Instruments recording system functioned very well in the cold, an aluminum box held a rugged laptop and 4 heating elements (with insulation). However, the Acousonde 3B performed poorly in the Arctic temperatures (-25C air), and power failures occurred multiple times before, during, and post-deployments, especially when transferring the instrument between the helicopter, the cold air, and the warm water. We are investigating alternatives for the 2013 season.

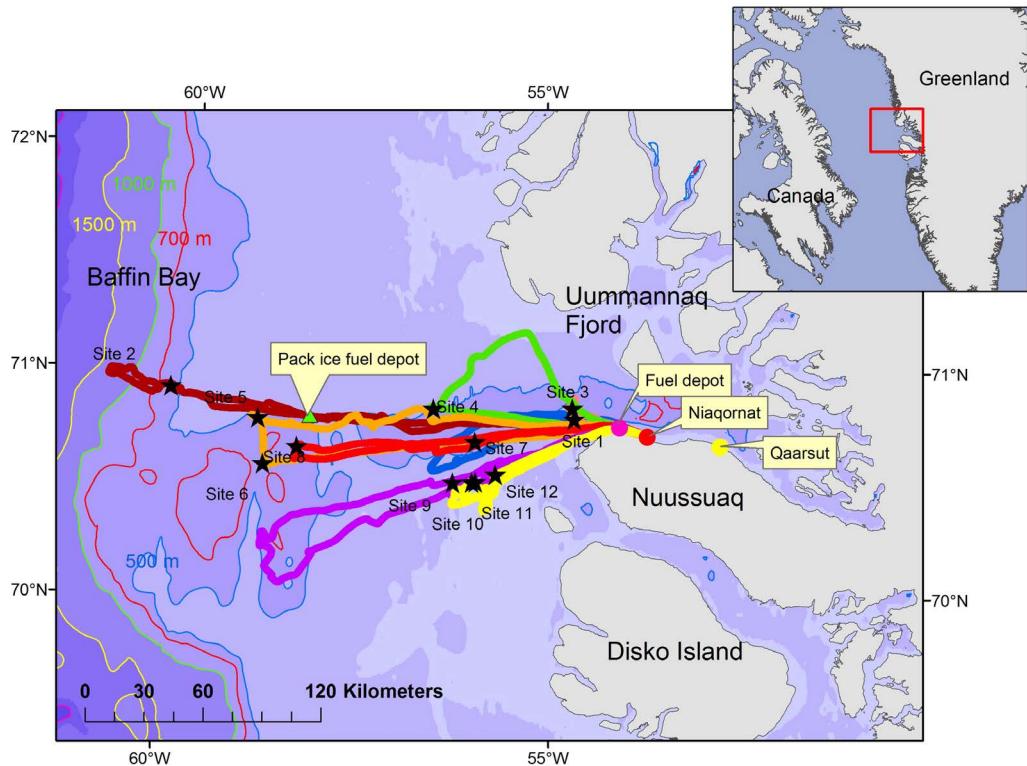


Figure 1. Map of helicopter tracklines and sampling sites in the offshore Baffin Bay pack ice during a pilot study March 2012. Colors represent individual daily flight paths and stars show each of 12 sampling sites where acoustic recordings were collected.

IMPACT/APPLICATIONS

1. New baseline information on the ecology of narwhals in the pack ice. This study will provide the first critical baseline data on acoustic foraging ecology of narwhals in an area rapidly being altered by increases in shipping, seismic exploration, and sea ice loss. We anticipate our results will be of broad interest to managers for predicting impacts of anthropogenic activities on this vulnerable species.

Potential future impact for Science and/or Systems Applications

1. New techniques for ecological studies of whales using telemetry. Our study develops technical and methodological advances for whale tagging in the Arctic. Design and deployment of satellite transmitters for whales will be refined based on field efforts during this project to improve attachment.

RELATED PROJECTS

None.

PUBLICATIONS

Laidre K.L., M. P. Heide-Jørgensen, H. Stern, P. Richard. 2012. Unusual sea ice entraps and delayed autumn freeze-up trends. *Polar Biology* 35: 149-154. DOI 10.1007/s00300-011-1036-8

Wiig Ø., Heide-Jørgensen M. P., K.L. Laidre, E. Garde, R Reeves. 2012. Geographic variation in cranial morphology of narwhals (*Monodon monoceros*) from Greenland and the Eastern Canadian Arctic. Polar Biology 35:63-71 DOI 10.1007/s00300-011-1032-z